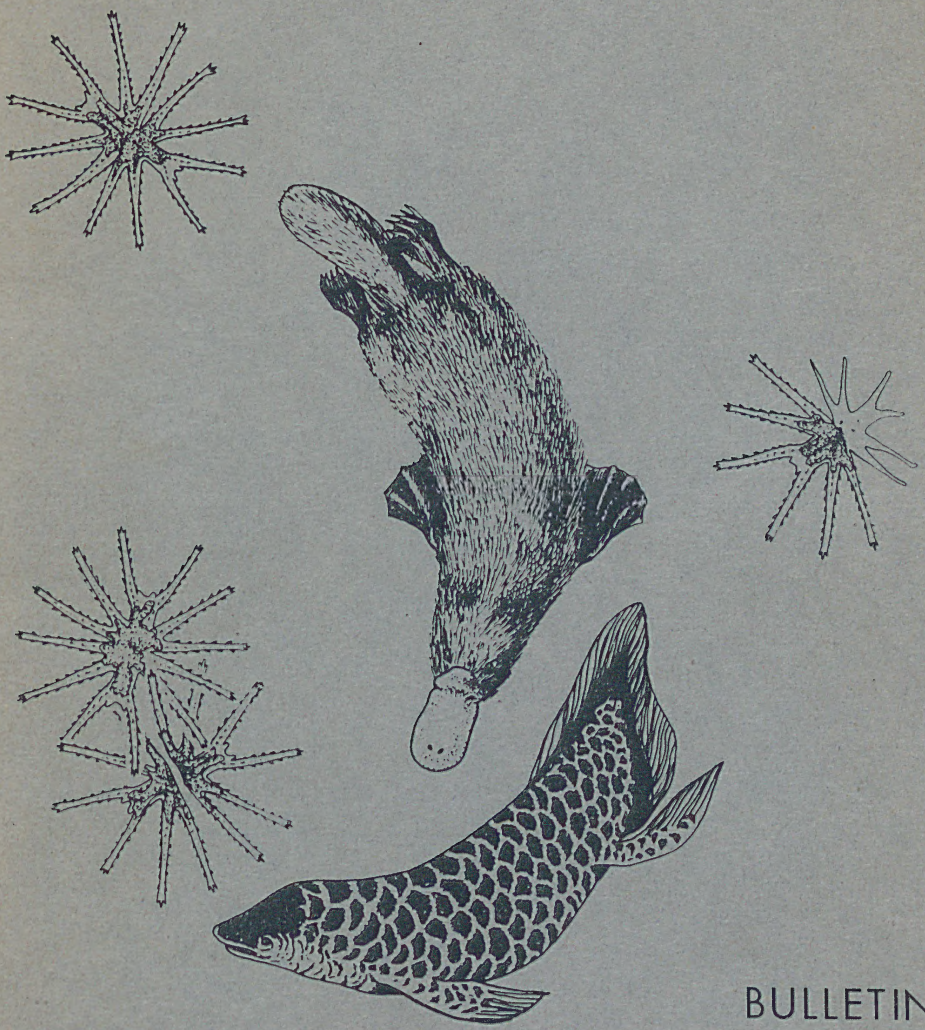
Australian Society for Limnology



BULLETIN
Nos. 1 & 2

EDITORIAL NOTE

Bulletin No. 1 of the Australian Society for Limnology was issued in October, 1969. In a number of respects, the quality of its printing left a great deal to be desired. Because of this, and because it has been decided to change the format of the Bulletin, Bulletin No. 1 is here reprinted. It immediately precedes Bulletin No. 2 which appears for the first time.

AUSTRALIAN SOCIETY FOR LIMNOLOGY BULLETIN NO. 1

OCTOBER 1969

Editorial Note

The title of the former Newsletter of the Society became a misnomer; it did not do justice to many original scientific contributions which were not communicated elsewhere, and these, not being "newsworthy" to all members of the Society, did not do justice to the title. Further, as the Newsletter fulfilled the accepted criteria of "publication", some problems arose when material intended to be merely preliminary communications was included in it.

For these and related reasons, it was decided at the 1968 Annual General Meeting of the Society and at the first succeeding Committee Meeting to attempt a more rational dissemination of limnological information by producing:

(a) a *Bulletin* which will be published irregularly and consist of contributed papers subject to the scrutiny of referees, papers or abstracts of papers presented at the annual congress of the Society, literature surveys, and, when appropriate, special materials; and

(b) a smaller but more frequent *Newsletter* than previously issued, and consisting of such items as book reviews, reports on the Annual General Meeting and Congresses and other meetings of the Society, personalia, notes on research in progress, and similar items. In future this will be marked "for private circulation only" and will be sent only to members of the Society. Material in this cannot, of course, be regarded as published. The "new" Newsletter will be numbered consecutively with the old one.

People presenting papers at annual congresses should take note that the appearance of these papers in the Bulletin constitutes publication. Consequently if they propose to publish the contents of their paper elsewhere they should specifically request that their paper appear in the Bulletin either by title only or in abstract form.

The Bulletin will be offically known as the *Australian Society for Limnology Bulletin* (abb. *Aust. Soc. Limnol. Bull.).* THIS, THE FIRST NUMBER, CONTAINS PAPERS, OR ABSTRACTS OF PAPERS, PRESENTED AT THE SEVENTH ANNUAL CONGRESS OF THE AUSTRALIAN SOCIETY FOR LIMNOLOGY. THIS WAS HELD IN RENMARK, SOUTH AUSTRALIA, IN MAY, 1968.

The Bulletin will be sent to libraries on the mailing list *free* of charge.

It is hoped that this split in the way in which information is to be communicated will lead to a more rational arrangement of written material, and, in the case of the reconstituted Newsletter, to a more effective liaison between members and a greater awareness of the Society's affairs.

Intending authors to the *Bulletin* are referred to the *Notes to Authors* on the last page of this issue.

The Editor

CONSERVATION OF FRESHWATER ANIMALS

(Abstract only)

by D.F. McMichael

*Director, Australian Conservation Foundation**

The problem of conservation of freshwater faunas in Australia was discussed generally and under three headings: the animals involved and the likelihood of conservation being required; the threats to them; and the conservation measures proposed.

Among the prominent animals involved and discussed are the platypus, water rats, water fowl and other aquatic birds, amphibians and reptiles, fishes, molluscs, insects and crustaceans. Some of these, such as the platypus, are now totally protected, but others (particularly the freshwater crocodile) are not, yet clearly need such protection.

Threats to Australian freshwater faunas are presented by (1) changes in stream flows as a result of water storage and flood mitigation, (2) increased siltation, (3) pollution by pesticides, sewage, industrial effluents, (4) introduced fishes, and (5) hunting. This sequence generally indicates the significance of the threats, but in the case of the freshwater crocodile, hunting is the major threat.

Conservation measures: Firstly, people concerned should try to ensure that planners of water storages, flood mitigation schemes, etc., take biological effects into account, and wherever possible attempt to limit these effects. This is particularly important for waterfowl and fish conservation. There is a need for a consultative council between Wildlife and Fisheries biologists on the one hand, and water conservation engineers on the other, with *recognition that conservation is important.* Secondly, soil conservation practices need to be improved to reduce the silt load of runoff. Thirdly, stricter pollution control legislation should be enacted and enforced, and a more restrictive control should be adopted with pesticides, particularly the persistent kinds such as chlorinated hydrocarbons and organophosphates. Fourthly, a greater effort should be made to obtain greater knowledge of the biology of native species and the effects on them of competitors. In some areas at least there is a need to restrict the spread of exotics. Pest species should be eliminated, and threatened species should be increased where possibly by controlled breeding and then distributed. Fifthly, with regard to hunting, total protection should be given to the freshwater crocodile, platypus, most waterbirds, the Queensland lungfish, and other vulnerable species. Such protection should be strictly enforced. A careful watch on fishing pressure was another conservation measure suggested, with the corollary that if needed, the catch and season be subject to a limit. And finally, special freshwater reserves should be created.

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THE ECOLOGY OF SEWAGE ORGANISMS: PART 1 – GENERAL

(Abstract only)

by Hilary Jolly

*M.W.S. & D.B., Sydney, N.S.W. 2000**

The methods of sewage treatment and disposal are of particular importance in a country such as Australia, where the slowly flowing rivers may be readily affected by pollution and where water shortage during droughts is becoming a serious problem. As about half of a city's water consumption enters the sewerage system, this with adequate treatment could be a potential supply for re-use.

Nature provides organisms capable of coping with all aspects of the purification of domestic sewage, if given sufficient time. Raw sewage usually has a very high percentage of organic nitrogen, is rich in phosphorus, has a very high alkalinity, and is low in dissolved oxygen. Modern methods hasten the natural processes by providing optimum conditions for the organisms to utilise the nutrients and hasten mineralisation. Polysaprobic bacteria and protozoa commence the digestion in tanks designed for their comfort. As the bacteria become numerous they are reduced by ciliates. After the primary treatment, exposure of the humus to the air by trickling filters or activated sludge basins assists oxygenation and enables organisms such as some species of algae and the Phytomastigina further to improve conditions by utilising carbon dioxide and giving off oxygen during photosynthesis. These organisms are in turn consumed by algal-eating protozoa, insect larvae and snails. Important final purification occurs in the oxygenation ponds, where large growths of algae may develop. Predators of both protozoa and algae are commonly rotifers, nematodes, oligochaetes, cyclopoids and cladocera. The latter are indicators of a good condition in the ponds.

A good quality effluent from sewage treatment works does add nutrients to a receiving stream but need not cause pollution if there is sufficient flow in the stream.

* Now resident in New Zealand.

THE ECOLOGY OF SEWAGE ORGANISMS: PART 2 – FACTS AND FIGURES

(Abstract only)

by Derek Cannon

M.W.S. & D.B., Warragamba, N.S.W. 2752

This paper deals with some of the organisms and the ecological factors relating to their periodicity and productivity at the Campbelltown sewage treatment works, N.S.W., during 1965 – 1966, and again in 1967 – 1968, when improved treatment methods reduced the alkalinity, and the use of an aerator in Pond 1 created different conditions which produced changes in the components of the Ponds.

Samples were taken from the humus effluent, Pond 1 and Pond 4, which are recovery ponds associated with tertiary treatment.

Three large graphs were exhibited showing variation in algal population and chemical and physical changes found throughout the two periods of observation.

From the graphs it was hoped to:

(a) Compare the data obtained for the two periods.
(b) Consider the difference in algal numbers and genera for the two periods.
(c) Attempt to correlate physical and chemical conditions with the various algae found.

Three slides showed the effect of the algal population on dissolved oxygen, pH, and total alkalinity at the three localities during two separate sampling runs over twenty-four hours in February and July 1966, which were made in order to compare summer and winter results. The effect of photosynthesis by the algae was most noticeable in both ponds during the summer run with high dissolved oxygen readings during the day and an associated rise in pH followed by a marked drop in dissolved oxygen and associated fall in pH as the result of respiration by the algae during the night. This pattern was repeated in the winter run but to a much less degree due to small numbers of algae, shorter days, and cooler temperatures. Fluctuations in the total alkalinity for the two runs were also discussed.

As this work at Campbelltown is still continuing and figures relating to the zooplankton populations have yet to be brought into the picture, it is hoped that some valuable facts relating to sewage organisms such as their role and requirements will be found.

THE DISTRIBUTION OF THE FRESHWATER CRAB, *HALICARCINUS LACUSTRIS*

(Abstract only*)

by K. Walker

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The distribution of a hymenosomatid crab species known from freshwaters in Victoria, South Australia, Tasmania (including King Island), the extreme north of New Zealand, and Lord Howe and Norfolk Islands was discussed. *H. lacustris* is of particular interest because the Hymenosomatidae is predominantly marine and estuarine.

The Victorian distribution was discussed in detail. Mainly, *H. lacustris* seems confined to slightly saline lakes and streams of Western Victoria, and is notably absent from the fresher waters of the Gippsland region. Natural populations of *H. lacustris* do not fully occupy the wide spectrum of salinity tolerance suggested by an experiment which demonstrated lethal limits of 0.0 and 37.0‰ salinity. In the field *H. lacustris* is largely absent from salinities beyond the range 1 to 10‰.

The absence of records from Gippsland fresh-waters ($\leqslant$ 1‰) is perhaps partly due to regional temperature differences. The differences in the salinity and temperature regimes of eastern and western Victoria are reflected in the different animal and plant communities. Also the predators of these communities may act as barriers to the dispersal of crabs. Competition is probably insignificant because of the omnivorous diet of *H. lacustris.*

Land connections are not a tenable explanation for the existence of *H. lacustris* in Australia and the three remote islands. Recent work by Lucas (1968) in Perth has revealed the existence of an estuarine sibling species, which appears to be the evolutionary precursor to *H. lacustris.* Thus the remote populations may be of polyphyletic derivation, although the estuarine species is presently not found elsewhere than around the south-eastern Australian coast. Another possibility is dispersal from the point of origin. An adventitious mode of transport would have been involved. Possibilities include transport by man, waterfowl, or, more probably, oceanic currents.

Little is known of the ex-Australian ecology of *H. lacustris.* There remains a wide scope for future investigations.

Reference

LUCAS, J.S. (1968). The biology of Australian species of the genus *Halicarcinus* White, 1846. Ph.D. thesis, Univ. W.A.

* Full details of the material presented in this paper, together with additional material, have been incorporated in the following publication:-

WALKER, K. (1969). The ecology and distribution of *Halicarcinus lacustris* (Brachyura : Hymenosomatidae) in Australian inland waters. *Aust. J. mar. Freshwat. Res.* **20** *: 163–73.*

A STUDY OF NILE PERCH IN AFRICA

(Abstract only*)

by S.H. Midgley

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The results of a study of the breeding habits, growth rate, environmental requirements and the temperature range and tolerance of the Nile Perch, *Lates* spp., were presented and discussed. The study was performed in Uganda, Africa, with the assistance of the East African Fisheries Research Organization at Jinja, and the Fisheries Department of Uganda at Entebbe. It was done during three months in 1968 when the author was a Winston Churchill Memorial Trust Fellow.

The object of the study was to gather information on the biology and habitat requirements of Nile Perch in order to determine whether it would be a suitable fish for introduction in waters in Northern Australia. The study was undertaken because of the inability to breed in impoundments of many Australian native fish conditioned to a stream environment. As a result, thousands of acres of inland waters are without fish of angling or commercial interest, a situation that would not be tolerated in many other countries.

Species of Nile Perch are endemic to Africa and complete their life cycle in lakes and streams. The closely related Australian species, *L. calcarifera,* the Barramundi, although capable of living indefinitely in fresh-waters, requires access to brackish or salt water to breed. This is one of our fishes that is adversely affected if denied access to fresh-water during the first two years of its life – i.e. by the creation of artificial barriers on streams.

As a result of the investigation, it is recommended that *Lates niloticus* be introduced to suitable waters in Northern Australia and the Territory of Papua and New Guinea.

* It is emphasised that the views expressed in this abstract are those of the author. Full details of the material presented in this paper, together with additional material, have been incorporated in the following publication:-

MIDGLEY, S.H. (1968). A study of Nile Perch in Africa (and consideration as to its suitability for Australian tropical inland waters). Winston Churchill Memorial Trust Fellowship Report No. 3.

THE RED ROCK LAKES

(Abstract only*)

by I.A.E. Bayly

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Near the south eastern shore of Lake Corangamite (Victoria) and close to the townships of Alvie and Coragulac there is a multiple scoria cone known as Red Rock or Red Hill. This paper deals with a cluster of seven small lakes associated with this structure.

The most outstanding chemical feature is the high pH which in all cases exceeds 9.0.

This clearly indicates the presence of carbonate and suggests that bicarbonate and carbonate are present in higher proportions than is typical of lakes in the western volcanic plains. Determinations of these ions and chloride showed that this was indeed the case, the equivalent ratio (HCO_3 + CO_3):Cl being as high as 0.74 in one lake (usually this ratio is less than 0.1).

The most significant biological feature is the presence in these lakes of *Boeckella triarticulata* not *Calamoecia clitellata.* The latter is an halobiont species characteristic of saline lakes in the Western District that are strongly dominated in the anions by chloride, and is found in some lakes that are distinctly less saline than some of those in the Red Rock series, (e.g. Lake Bullenmerri). It is suggested that large amounts of (bi-)carbonate exclude *C. clitellata* but permit the penetration of *B. triarticulata*, an essentially freshwater species, into quite saline water.

The point emerges that in studying the ecology of salt lakes, and the physiology of salt-lake animals, we should take cognisance of ionic proportions as well as salinity.

* Full details of the material presented in this paper, together with additional material, have been incorporated in the following publication:-
BAYLY, I.A.E. (1969). The occurrence of calanoid copepods in athalassic saline waters in relation to salinity and ionic proportions. *Verh. int. Verein. theor. angew. Limnol.* 17.

ENERGY TRANSFORMATIONS IN SALT LAKES

by W.D. Williams

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Most aquatic ecosystems are tremendously complex units. However, many difficulties inherent in trophic dynamic studies of inland waters are minimized in salt lakes. Thus, one main difficulty, biotic diversity, is much less a hurdle in saline lakes than in freshwaters. Exact indices of diversity for salt lakes cannot yet be given, but undoubtedly diversity decreases with increasing salinity. Taxonomy does present a hurdle in Australia, but although true in absolute terms, relatively the hurdle is much lower in Australian salt lakes than in the freshwater ecosystems of biologically better known regions of the world.

There is one other important aspect of diversity. Normally, total primary productivity in lentic localities derives from three sources: periphytic, macrophytic, and phytoplanktonic. Many primary productivity studies for lakes have been restricted to phytoplankton determinations, but macrophytic and periphytic contributions can also be important. At least in *highly* saline lakes, and to a large extend in less saline ones, the macrophytic component, probably the most difficult to evaluate because of underground production of material, is virtually absent. Furthermore, because most saline lakes are shallow, and therefore more thoroughly mixed than deeper freshwater lakes, problems of spatial heterogeneity of phytoplankton leading to sampling errors and of deriving integral photosynthesis are probably minimized. Shallowness also conveys advantages related to sampling techniques.

Furthermore, freshwater ecosystems are open systems, and whilst this may be of no great concern for lentic localities (especially those with low renewal rates), the determination of how much organic material is lost by downstream drift poses certain problems in lotic ecosystems. In saline lakes there is no aquatic surface loss of organic material because they are the discrete termini of inland drainage systems.

Having advanced some reasons for studying saline lakes from the trophic dynamic aspect, two questions arise. In view of their suitability for study as complete ecosystems, why is it they have not been so studied this far? And, secondly, what is the present status of our knowledge concerning salt lake metabolism? A partial answer to the first question has been given by Bayly and Williams (1966). Salt lakes generally occur in arid regions

and are largely inaccessible for continuous study. There appear to be only few exceptions. Regarding the second question, the answer is that little is known, but a beginning has been made. For example, some primary productivity determinations have been made on Borax Lake, California, a moderately saline lake by our standards, by Wetzel (1963, 1964). Less continuous data on phytoplankton primary production have been given for some salt lakes of the East African Rift Valley by Talling (1965). And Goldman, Mason and Hobbie (1967) have provided similar data for two Antarctic saline lakes. Nobody has yet studied the complete energetics of salt lakes, despite the relative simplicity.

Expectedly, Goldman *et al.* (1967) found extremely low rates of production; a figure for photosynthetic uptake is quoted of 14 mg C m^{-2} day^{-1}. Wetzel (1963, 1964), on the other hand, found productivities higher than most freshwater productivities. He quotes the total annual mean primary productivity as 1,057 mg C m^{-2} day^{-1}, which is higher than that recorded for a variety of freshwater lakes in Denmark (all with values < 750 mg C m^{-2} day^{-1}) with the exception of the shallow, eutrophic and mildly polluted Sollerød with 1,430 mg C m^{-2} day^{-1} (Steemann Nielsen, 1955). This is not astonishing for the *apparently* high secondary production of many Australian salt lakes (as indicated at least by standing crops) is impressive.

The basis of such apparently high secondary production raises interesting questions as to what is involved, its abundance and periodicity, and the actual mechanism of energy transfer. Within Victorian salt lakes, according to S.U. Hussainy (pers. comm.), the principal plant below salinities of *ca.* 60 gms/l is the blue-green *Nodularia;* at higher salinities the chlorophycean *Dunaliella* is the plant principally involved. Although his data on chlorophyll *a* content show little correlation with salinity, and although various criticisms can be raised against the extrapolation of phytoplanktonic pigment abundance to indicate either standing crop or primary productivity, his figures nevertheless indicate great phytoplankton abundances over wide salinity ranges.

Nodularia characteristically forms blooms in some Victorian salt lakes (e.g. Lake Corangamite) and it is interesting to postulate that this phenomenon may sometimes play an important role. Some blue greens almost immediately secrete up to 50 per cent of the carbon they fix by photosynthesis (Fogg, Nalewajko and Watt, 1965). Such soluble organic material may then serve as the food of heterotrophic bacteria either during the bloom or perhaps afterwards, and these in turn may serve as food for filter-feeding animals. It is known that such relatively large animals as *Simulium* larvae can live exclusively on bacteria (Fredeen, 1960). Remotely perhaps, bacteria may not be involved; Provasoli and Shiraishi (1959) have raised *Artemia* axenically in a medium of various dissolved organic substances, liver infusion, and starch particles (the latter initiate feeding movements). In a sense this hypothesis is akin to one of Goldman *et al.* (1967) who suggested that heterotrophic nutrition based on extra-cellular secretory products enabled algae in Antarctic lakes to persist during the dark and long winter. In the present case, a period of unfavourably high salinity might be equated with the long dark winter, and secondary production to heterotrophic algal nutrition.

Large numbers of nannoplankton ($\leqslant 10\ \mu$) may be involved. Kalff (1967) and Goldman *et al.* (1967) clearly demonstrate the greater importance of this vis-a-vis net phytoplankton in the Arctic and Antarctic. With information from hypertrophic central European lakes, Pavoni (1962) suggested a relationship between extreme conditions and nannoplankton abundance.

Finally, mention is made of the possibility of sensible amounts of allochthonous organic material as a primary energy source (as wind-blown pollen and other terrestrial plant matter). Allochthonous material certainly forms the main energy source for streams (cf. Hynes 1963), and contributes, though far less significantly, to the energy budget of lakes (cf. Szczepanski, 1965). Indeed it is mainly allochthonous organic material that causes the hypolimnetic areal deficit to be so poor an indication of lake productivity. Hutchinson (1937) has already named those lakes receiving large amounts

of wind-blown fixed carbon as "anemotrophic". The allochthonous material itself has also been named; Steinbock (1958) called it "empneuston" and referred to lakes whose food chain basis lay outside the lake proper as allotrophic.

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THE OSTEOGLOSSID, *SCLEROPAGES LEICHHARDTI*

(Abstract only)

by J.S. Lake

Zoology Building, The University of Sydney, Sydney, N.S.W. 2006

This bony-tongued fish practices buccal incubation (a mouth brooder) and possesses two small barbels on the lower jaw.

There are only four genera and five or six species distributed in Africa, America, Indo-Malay area, Southern New Guinea and the Gulf of Carpenteria, and tributaries of the Fitzroy River System which enters the sea at Rockhampton on the Tropic of Capricorn. There are several fossil species dating back to the Eocene period and some authorities regard this fish and the Queensland lung fish, *Neoceratodus fosteri,* as the only true freshwater fishes in Australia.

Scleropages leichhardti (the spotted barramundi) is confined to the one river system – the Fitzroy (I believe the specimens occurring in the Gulf of Carpentaria are a distinct species). Earlier references to its occurrence in the Burdekin River are almost certainly incorrect. This latter river does not present the type of habitat suitable for *Scleropages* and although Gunther mentions the Burdekin River in his original description he also states that the specimen was taken in a creek about 90 miles from Rockhampton. This must be the Fitzroy system and checking with Ludwig Leichhardt's diary the specimen described by Gunther probably came from Roper Creek near its junction with the Mackenzie River – a tributary of the Fitzroy River.

Scleropages is a slow water fish, spawns when water temperatures reach 20°C, will spawn in a small (¼ acre) shallow (5' deep) pond. A 2½ kg. fish produces only about 200 eggs which are over 10 mm. in diameter, and spawning probably occurs at three years of age. Young fish, still with the yolk sac attached are 3.8 cm. in total length. High turbidity is tolerated; in the Dawson River a Secchi disc reading of 3.8 cm has been recorded, and temperature tolerance tests show that they will live in water between 7 and 40°C. However, prolonged exposure below 10°C (for periods of three or four weeks) results in death. Surface temperatures in the Dawson River have been recorded from 13 to 33°C. The total length reached at the end of the first year averages about 28 cm.

This fish feeds mainly on terrestrial insects and provides excellent sport on a dry fly and will leap completely out of the water. Its edible qualities are good.

AUSTRALIAN SOCIETY FOR LIMNOLOGY BULLETIN NO. 2
FEBRUARY 1970

Editorial Note

THIS NUMBER CONTAINS PAPERS, OR ABSTRACTS OF PAPERS, PRESENTED AT THE EIGHTH ANNUAL CONGRESS OF THE AUSTRALIAN SOCIETY FOR LIMNOLOGY. THIS WAS HELD AT JINDABYNE, NEW SOUTH WALES, IN FEBRUARY 1969.

ECOLOGICAL ASPECTS OF AN ALPINE ENVIRONMENT

(Abstract only)

by D.J. Wimbush

C.S.I.R.O. Division of Plant Industry, Jindabyne, N.S.W. 2627

Vegetation on the eastern slopes of the Snowy Mountains follows an altitudinal sequence, starting with savannah woodland in the valley around 1,000 m and rising through montane sclerophyll forests and subalpine woodland to alpine herbfields above the treeline. Within the alpine tract, exposure to wind and accumulation of snow are reflected in a topographic sequence.

The work of the Alpine Ecology Section of CSIRO has been concerned with the effects of different forms of land-use on vegetation and hydrology.

More than a century of summer grazing and light burning of alpine and subalpine areas have caused marked changes in both the quantity and diversity of vegetative cover. After grazing was discontinued in 1958 above 1,500 m, quantitative data show that both ground cover and number of species have greatly increased.

Hydrologic studies on different vegetation types have shown that run-off and soil-loss are minimal in dense snowgrass and shrub types, and that mature stands of snowgum are effective barriers to windblown snow and cloud, thereby increasing total precipitation. Sphagnum bogs have less of a regulatory role in catchment hydrology than was previously thought, and evaporate more water than grassland. They do, however, perform a useful role in stabilising drainage channels.

Extensive areas of subalpine woodland have been nearly denuded of trees by grazing following the 1939 fires, and seed sources virtually eliminated. Planting trials have commenced and, if successful, will lead to an increasing area being planted to snowgums each year.

Planting both native and introduced species on eroded areas at high altitudes has so far been successful with only a small number, among them *Trifolium ambiguum,* a Caucasian clover undergoing selection trials, which will be planted out when sufficient material is propagated.

A recent examination of differences in water-use by a pine plantation and the native forest it replaced has revealed that during dry spells the pine forest extracts water at a rate 5–10% higher than the eucalypt. This difference appears to be correlated with a 5–1% difference in albedo, which was measured with a total net radiometer flown across the canopy.

Historical studies have included radiocarbon dating of material collected from the base of solifluction terraces, buried peat and sediments in Blue Lake. General conclusions are that epicyclic periglacial activity has occurred during the last 300 years but that the last widespread solifluction was 2,000–3,000 years ago.

CURRENT FISHERIES RESEARCH ON LAKE EUCUMBENE

by R.D.J. Tilzey

Fisheries Branch, Chief Secretary's Department, Sydney, N.S.W. 2000

Eucumbene is the largest of the water-storages created by the Snowy Mountains Hydro-Electric Scheme. Inundation of the reservoir basin commenced on 21st June 1957. The water level steadily rose until late in 1961 and remained fairly constant until 1967 – 68, when a large fall was experienced because of prolonged drought. The relatively heavy precipitation of the 1968 winter brought the lake back to its former level. Full capacity has not yet been reached. The highest recorded level to date was 1148.1 m above sea-level in 1964; a depth of nearly 76 m at the dam wall. When at full capacity Eucumbene will have a surface area of 145.4 km^2, a volume of 4,798 x 10^5 m^3, and a depth of 92.7 m at the dam wall.

Eucumbene is typically oligotrophic, being poor in dissolved nutritive material. Its water has a high transparency and minimal quantities of suspended detritus. Dissolved oxygen is relatively constant from top to bottom, extending over a range of 9.7–11.6 p.p.m. in winter months and 5.8–8.4 p.p.m. in summer months. Very little putrefaction occurs in the bottom deposits. Littoral plants are sparsely distributed (also as a consequence of the fluctuating level) and plankton production is poor.

Eucumbene is slightly acidic, exhibiting a pH range of 6.4–7.1 during the period 1965–68. The mean hardness (EDTA) for this period was 17 p.p.m., and monthly mean water temperatures ranged between 6.4 and 20.1°C at the surface and 5.6 and 9.2°C at 50 metres depth, the respective lows and highs occurring in July and February, and September and March. Thermal stratification appears in late December and the metalimnion has a vertical range of 6 metres (15–20 m depth) and a temperature gradient of 4°C (15–11°C). It persists through to late March, by which time the metalimnion is found between depths of 22 and 30 metres.

N.S.W. State Fisheries Department's interest in the lake is prompted by the lake being Australia's major trout fishery. Two species are present, the rainbow trout, *Salmo gairdneri* Richardson, and the brown trout, *S. trutta* L.. The initial inundation of the reservoir basin resulted in a great increase in trout production. The average weight of brown trout reached a peak of 1.985 kg in 1959–60 and that of rainbow trout a peak of 1.304 kg in 1960–61. These weights were calculated from data provided by relatively few licence returns and should not be taken as highly accurate. Such production was, of course, prompted by the availability of large quantities of terrestrial invertebrates and the temporary abundance of dissolved nutrients during inundation. As expected, once a "constant" level was reached, trout production declined.

The growth rate of rainbow trout has remained relatively stable over the past five years. However, this is not the case with brown trout and the growth rate is still declining (Table 1).

TABLE 1

MEAN LENGTHS OF BROWN AND RAINBOW TROUT

(All fish age V and taken during August; lengths in cm)

Year	Brown trout	Rainbow trout
1965	58.0	49.1
1966	54.7	49.3
1967	49.3	51.8
1968	47.8	49.6

A closer look at the growth rate of brown trout reveals a marked decline during the third year of life. Brown trout and rainbow trout exhibit similar growth patterns. The first year of life is spent in the spawning stream and the majority of fish enter the lake during their second year. Annual increments increase until age III and then decline (Table 2).

TABLE 2
GROWTH OF A TYPICAL BROWN TROUT

Age	I (1963)	II (1964)	III (1965)	IV (1966)	V (1967)
Length	8.4 cms	21.0 cms	36.4 cms	46.9 cms	49.3 cms
Annual increment	0–I 5.9*cms	I–II 12.6 cms	II–III 15.3 cms	III–IV 10.5 cms	IV–V 2.4 cms
Specific growth rate	127*	86	55	25	5

* Assuming fish to be 2.5 cm long when first starting to feed.

Comparison of the third years of age V brown trout taken in 1967 (Table 2) with those taken in 1965 and 1966 show the specific growth rate to have declined; those of 1965 and 1966 fish were 78 and 67 respectively. Thus the specific growth rate in this third year of life has fallen by 11 and 12 in successive years. More recent figures show this trend to be continuing, although being of less magnitude. The specific growth rates of the other years of life have remained relatively constant. However, the reduced growth rate during the third year is naturally resulting in smaller age III, IV and V fish.

The Eucumbene research programme is directed partly at determining the cause of this decline in brown trout growth and implementing fishery management procedures to prevent it from continuing, and mainly at determining it the catch returns to the angler can be improved.

The rainbow trout is much more of an angler's fish. Returns from fish tagged during the winter of 1966 showed 22.7% of rainbow trout in the III–V age groups to be caught in the following 12 months, whereas only 6.9% of brown trout of similar age were caught. The brown trout population is largely untapped by the angler even though it is at least twice the size of the rainbow trout population. The 22.7% return for rainbow trout is high and may, at first glance, be thought to have been caused by a high incidence of unusual catches. However, returns at present coming in for fish tagged in 1968 confirm that the more recent figures will be of the same magnitude. Eucumbene has a rapid "turn-over" of fish. Out of the thousands of fish sampled only three age VI fish have been found and the usual life expectancy would appear to be five years only.

To date, brown trout have never comprised more than 33% of the catch although the figure for the 1968–69 season looks like being higher. The catch-per-effort (expressed as number of fish per angler-hour) has been significantly lower for brown trout. For example, during the 1966–67 season (that following tagging) the catch-per-effort for brown trout was 0.08 (12.5 hours per fish) as against 0.22 (4.4 hours) for rainbow trout.

Obviously, rainbow trout are more freely exploited than brown trout. Any steps taken to improve the standing crop of rainbow trout would automatically improve the quality of the fishery, even if such steps were made at the expense of the brown trout population. What steps, if any, should be taken?

Answering these questions involves several studies. For example, both species of trout have somewhat similar diets. Is competition for food having a detrimental effect upon the fishery? Likewise, do the species compete for spawning space? In short, the Eucumbene programme involves a study of the lake as a dynamic whole with the emphasis being on the dynamics of the trout populations.

The crux of the matter can be said to be food availability. A knowledge of the quality, quantity, and factors influencing the production of Eucumbene's food organisms is an essential base from which to assess the optimum standing crop of fish that should be carried. Likewise the continuing decline in size of the brown trout could be caused by one, or all, of three reasons.

1. Has there been a decline in the overall energy-content of the lake? By virtue of its role in the Snowy Mountains Scheme, Eucumbene is not a stable lake. Whereas in a completely enclosed water the nutrients would continually be re-cycled, this is not the case with Eucumbene for large volumes of water are frequently drawn off. This could be resulting in a gradual decline in available nutrients. Comparisons between T.D.S. readings taken over the period 1958–68 have as yet revealed no "sinister" trends, but nevertheless such sampling will continue. No quantitative plankton samples have been collected up to now but concurrent sampling will commence this year with the aim of using zooplankton production as an index of the lake's productivity.

2. Are the trout making use of the available food organisms? Should, for example, an intermediate forage species be introduced? Apart from trout, the lake contains few other fish. A small population of crucian carp *(Carassius carassius* (L.)*)* is present and these have been found in the stomachs of trout. However, they are not plentiful and do not appear likely to become so. Their growth is slow in comparison with that in warmer waters and Eucumbene temperatures are probably below the desired optimum. The total carp population is so small as to be considered insignificant when considering their value as trout-food. A few river blackfish *(Gadopsis marmoratus* Richardson*)* have been recorded but the change from a lotic to lentic environment seems to have resulted in their drastic decline. *Galaxias finlayii* (MacLean) occurs in some of the feeder streams but has not been recorded from the lake. *Anguilla reinhardtii* (Steindachner) and *A. australis* (Richardson) have both been recorded but will undoubtedly disappear, if they have not already done so, as the dam wall forms an effective barrier against incoming juveniles.

Available data indicate that the introduction of a forage species would be undesirable. The trout appear to utilise the food sources available and the introduction of an intermediate link in the food chain would only serve to reduce existing conversion efficiency. However, much work remains to be done before the position is clear. Qualitative and quantitative data must be obtained for the major food items, and forage ratios and the like, calculated. A pilot survey of the trout's stomach contents during the summer months (November–March) has been made and the frequency of occurrence of the major groups recorded (see Table 3).

The frequency of occurrence is only a rudimentary guide to the relative importance of each group. Percentage dry-weight is the standard to be adopted, but whereas the number and type of organism in each stomach have been recorded, dry-weight values for individual organisms have yet to be calculated, and figures are not at present available. Insects are by far the most important food item during summer months. The Odonata undoubtedly constitute the major group in terms of dry-weight. The fish sampled ranged in size from 34–55 cms and were between III+ and V+ years of age. The diets of both species are essentially similar and it appears probable that there is interspecific competition for food. Brown trout do, however, show more evidence of bottom feeding than rainbow trout.

TABLE 3
STOMACH CONTENTS OF TROUT OF AGE III+ TO V+
(percentage occurrence)

Taxon	Brown trout (166 fish)	Rainbow trout (159 fish)
Annelida	2.4	1.9
Gastropoda	13.2	3.1
Lamellibranchiata	3.6	0
Cladocera	8.4	20.1
Cherax sp.	2.4	0
Ephemeroptera	1.2	1.9
Odonata (nymphs)	61.2	60.4
(adults)	2.4	5.7
Plecoptera	6.0	2.5
Corixidae	37.2	51.6
Other hemipterans	4.8	10.7
Coleoptera (aquatic)	6.0	23.3
(terrestrial)	32.0	20.1
Trichoptera	10.8	20.5
Diptera (larvae)	36.0	35.8
(pupae)	90.0	67.3
(adults)	2.4	5.0
Lepidoptera (terrestrial adults)	1.2	1.3
Hymenoptera (terrestrial adults)	4.8	6.9
Orthoptera (terrestrial adults)	1.2	1.3
Carassius	1.2	0
Amphibia	6.0	5.7
Number of empty stomachs	2.0	0

Of particular interest is the high incidence of daphnids in rainbow trout stomachs. Such a state of affairs gives a very efficient conversion of primary producers into trout flesh, assuming that the fish do not expend excessive energy in catching such daphnids. Up to 8150 daphnids have been recorded in a single stomach, with *Daphnia carinata* (King) comprising the bulk of such organisms. The period November to March cannot be taken as being representative of the year as a whole. The comparative paucity of insect life during winter months results in other invertebrate groups, such as the molluscs, becoming of major importance.

Fish of age I+ are difficult to obtain owing to the topography of the lake. Such fish frequent submerged forest and heavily snagged areas unsuitable for either gill-netting or seining. Eighty-eight small rainbow trout only have been taken, ranging in length from 93–169 mm. From this comparatively small sample it is evident that daphnids. chironomids, and Odonata constitute the major food items. The frequency of occurrence is indicated in Table 4. Adult Diptera, Coleoptera, and Hymenoptera were also recorded in a few stomachs. Up to 3072 daphnids and 791 chironomids were recorded in single stomachs. No I+ brown trout have been taken to date.

TABLE 4

STOMACH CONTENTS OF EIGHTY-EIGHT SMALL RAINBOW TROUT

(percentage occurrence)

Taxon	Occurrence
Daphnia sp.	52
Chironomid larvae	100
Chironomid pupae	95
Odonata larvae	37
Hemiptera	19
Trichoptera	19
Empty stomachs	0

As mentioned previously, the above sampling was only to serve as a pilot. Monthly stomach sampling will commence in April 1969 and extend over a minimum of 12 months. Such sampling will be conducted along with investigations into the benthos, and forage ratios will be calculated. Although the position is as yet far from clear, available data do not suggest that a forage fish be introduced.

3. Is the number of fish comprising the trout population increasing, thereby lowering individual food availability? This is the most likely cause of the continuing decline in size of the brown trout. Relatively good spawning facilities, together with the previously mentioned low exploitation, could be leading to a build-up of the brown trout population. Such an increase in number would also have an adverse affect on the rainbow trout population.

The dynamics of both trout populations are therefore being studied. The first problem posed is that of obtaining a numerical estimate of each population. The straightforward tag and release procedure has been adopted. Netting, and similar procedures, have been found to recover few tags, owing to the large number of fish comprising each population. The onus on tag-return has thus been placed on the angler.

Three hundred and eighty brown trout and 400 rainbow trout were tagged in 1966. As mentioned previously 6.9% of the brown trout and 22.7% of the rainbow trout tags were recovered. Unfortunately no population estimate could be made owing to the poor response from fishermen in submitting catch data.

Last winter (1968), 1500 brown trout and 400 rainbow trout were tagged. A monel-metal strap tag affixed to the operculum was used, as in 1966. Two-thirds of the fish were double-tagged in order to obtain an estimate of tag loss. To date (1.3.69) 6.6% of the brown trout tags and 15.3% of the rainbow trout tags have been recovered and it appears likely that the final figures will be of the same order as for 1966. At first glance this would indicate the existence of a relatively stable population, but the catch-per-effort for brown trout this season is, for some reason, much higher. The tagging programme has been given greater publicity than in 1966 and angler co-operation is much improved. Sufficient catch data are coming in and population estimates will shortly be available.

All the fish were trapped and tagged during their spawning "runs" in Gang Gang Creek, Swamp Creek, and the Eucumbene River (Fig. 1). Recoveries have been coming in from all corners of the lake and the tagged fish can thus be assumed to have become freely dispersed. The density of tag-recoveries is directly proportional to the fishing pressure on the area concerned; the great proportion of tags come from the immediate vicinities of boat hire sites.

Tag loss to date is 11.6% for brown trout and nil for rainbow trout. This probably reflects the feeding behaviour of each species, the brown trout being more in the habit of "grubbing" amongst stones, timber and the like. Such behaviour would lead to the tags being rubbed off. In all cases of tag loss, the operculum has split along the line of the tag.

All the fish tagged were in the III–V age group and the final population estimate will have to be adjusted to allow for natural mortality. The numerical ratios between each year group also have to be obtained. The problem of obtaining a regular sample of fish without size bias has proved insurmountable. The substratum is too irregular for seine-netting and the water unsuitable for electric shocking equipment, being low in electrolytes. Gill nets are the only equipment that consistently take fish, and such gear is too selective, despite using mesh sizes ranging from 3.71–13.97 cm in 1.27 cm increments. However, one can obtain a good representative sample during the spawning run by using fixed traps and drum-nets, with a non-selective funnel-entrance. These samples can be used as indices. Gill nets, whilst being selective for size, are not selective for sexual maturity. The percentage of fish in each year group maturing to spawn in the coming (1969) winter is being calculated. This datum will be used, together with that obtained from fish trapped in the spawning run, to provide an estimate of population composition, in terms of size, sex, and age-groups. Recruitment and annual mortality can then be calculated.

Catch data do not provide a clear picture. We receive details of the species, sex, length and weight but not the age. Because of the size of the lake, the habitat and life-history of individual fish often differ from its neighbours. Age cannot be deduced from fish-length. For example, in 1967 a sample of 1100 fish showed the lengths in each age group to have a wide range (Table 5).

TABLE 5
SIZE RANGE OF DIFFERENTLY AGED FISH
(values as cm)

Age	Brown trout	Rainbow trout
III	28–46	24–47
IV	33–51	32–54
V	41–64	42–56

Using catch data from more than 8000 fish greater than 25 cm in length, an almost straight line was obtained for a length-frequency plot, the number of fish decreasing with increasing size. No age peaks were discernible even though these fish were all caught in a ten week period only. The 45^{o} angle of this plot suggests a 50% annual mortality after age III, but this cannot be taken as accurate.

Sex ratios cannot be accurately deduced from the catch as the tagging returns show male fish to be more liable to capture by angling. To date (1.3.69), 17.5% of tagged male rainbow trout have been returned, as against 12.5% of the females. The corresponding figures for brown trout are 8.8% and 5.3% respectively.

The spawning run in Swamp Creek was trapped last winter for the period 1.6.68 to 10.10.68. This creek was chosen because of its general accessibility and its structural similarity to the Eucumbene River, the major spawning stream. Every fish ascending the creek was trapped and sampled for length, age, etc.. Some rainbow trout leapt over the retaining barrier during the large spate of 26.8.68 to 27.8.68 but no brown trout are thought to have escaped. Concurrent trapping in the Eucumbene River using small drum nets showed the Swamp Creek fish to be representative of the spawning run as a whole.

Length-frequencies are shown in Table 6. Of 2546 brown trout that were trapped, 68% were females and 32% males. This 2:1 female to male ratio is not unusual in spawning runs, and overseas workers have observed the same. Male fish are thought to have a higher natural mortality than females. That they also experience a higher angling mortality is indicated from the above tag returns. The length frequencies peak at 43–46 cms. Only 300 scales have yet been read but the percentage by age would appear to be in the order

of age III 18%, IV 54% and V 28%. Obviously only a small proportion of brown trout spawn at age III. Here again, if one assumes that an equal proportion of IV and V fish matured to spawn in 1968 the annual mortality from age IV–V would be in the region of 50%. However, this is only an assumption.

Four hundred and seven rainbow trout were taken, but as mentioned some escaped capture. The length-frequency slope is more gradual than that for brown trout. Fifty-three percent were females and 47% males. No scales have as yet been read. Because of the comparatively small number of rainbow trout taken, the length frequency chart also incorporates fish taken in similar traps in Gang Gang and Hughes Creek (a total of 760 fish).

Fecundity counts were made on 102 female brown trout but none were performed on rainbow trout because the ova were required for the Gaden Trout Hatchery. The exact relationship between fish weight and egg number has yet to be determined. However, it is apparent that in 1968 Swamp Creek would have in the region of 3.5×10^6 brown trout ova deposited in it.

Many of the Swamp Creek fish were tagged. Whilst such tagging was carried out with the abovementioned statistical aims in mind, it also provided some insight into the movements of spawning fish. Brown trout remained in the creek for up to 76 days and rainbow trout 39 days. Both species moved upstream when the water level was rising and downstream when it was falling, with water temperature remaining constant. Both ripe and spent fish exhibited this behaviour. Three brown trout tagged in the Eucumbene River 1.6 km upstream of the Swamp Creek inflow, were recaptured in the Swamp Creek trap 22, 26 and 27 days later. This involved a downstream journey of 1.6 km followed by an upstream journey of similar distance. Seven brown trout performed the same journey in reverse, taking periods of up to 44 days. One spent rainbow trout female took four days to travel from Gang Gang Creek to a trap sited 1.2 km upstream in Hughes Creek; a journey involving 3.2 km downstream and 1.2 km upstream. An attempt will be made to relate these movements to changes in the environment, during the 1969/70 spawning seasons, although such behaviour is incidental to the Eucumbene programme.

It is anticipated that a comprehensive study will be conducted on the spawning and subsequent fry and fingerling mortality of both species in Swamp Creek, during 1969/70. All fish entering the creek during the 1969 winter will be trapped, sampled, and then allowed to proceed upstream in the normal manner. An accurate estimate of the number of ova deposited will be obtained by ulitizing fecundity data at present on file, together with those from fish sampled elsewhere in 1969. The creek will then be sampled at regular intervals during the following 18 months to assess survival and mortality of the juvenile trout. Another creek, Gang Gang, will have a barrier placed across it, preventing lake fish from proceeding upstream and will be sampled in a similar manner. The contribution that resident stream fish make to annual recruitment will thus be evaluated. The information this gained is applicable to Eucumbene as a whole and will be of substantial use in estimating the number of recruits which annually enter the lake. There is a heavy spawning pressure on the suitable gravel available and ova, fry and subsequent mortality is undoubtedly heavy. For example the stomachs of 91 trout in the Eucumbene River were sampled last winter and the percentage occurrence of ova was 82%, up to 780 ova being found in a single stomach. No appreciable difference between brown trout and rainbow trout, and spent or ripe fish was recorded.

This account serves only as a resumé of current research. No positive conclusions can as yet be drawn.

TABLE 6
LENGTH FREQUENCY DATA
(Data for Brown trout from Swamp Creek only; data for Rainbow trout from Swamp, Gang Gang and Hughes Creeks)

Length (mm)	Brown trout			Rainbow trout		
	♀	♂	Total	♀	♂	Total
301–310	1	1	2	0	2	2
311–320	2	9	11	0	1	1
321–330	4	4	8	0	1	1
331–340	11	7	18	0	1	1
341–350	16	9	25	0	1	1
351–360	30	13	43	4	1	5
361–370	36	26	62	1	5	6
371–380	52	36	88	7	4	11
381–390	72	33	105	5	4	9
391–400	92	48	140	14	14	28
401–410	120	52	172	13	25	38
411–420	142	62	204	27	41	68
421–430	159	65	224	47	41	88
431–440	204	43	247	40	40	80
441–450	171	74	245	46	29	75
451–460	194	54	248	44	27	71
461–470	151	69	220	42	18	60
471–480	125	65	190	29	23	52
481–490	70	53	123	34	12	46
491–500	55	34	89	21	22	43
501–510	23	15	38	27	17	44
511–520	9	6	15	14	5	19
521–530	4	9	13	1	3	4
531–540	2	6	8	1	2	3
541–550	2	3	5	4	0	4

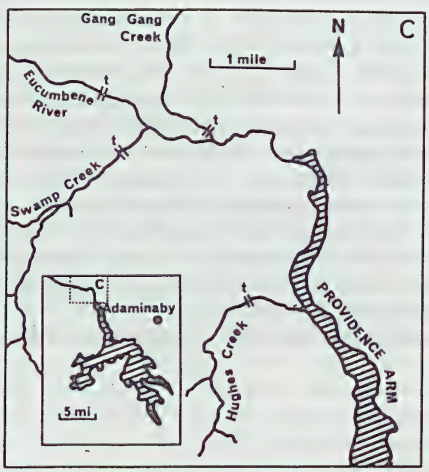

Fig. 1 Localities referred to in the text. t = trapping site.

THE HISTORY OF A COASTAL LAKE AT WILSON'S PROMONTORY, VICTORIA

(Abstract only)

by G.S. Hope

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Cotters Lake is situated about 6.4 km north of Darby River on the western side of the Yanakie isthmus which joins Wilson's Promontory to the mainland. At the present day it is really a large swamp about a mile across, usually dry, but with up to 0.6 m of water after rain. There is no drainage into the lake as it occurs on Pleistocene calcarenite dunes, and the level presumably reflects the water table. When full of water the lake drains to the sea by a channel cut in the low sand dune separating it from the beach. Most of the swamp area is vegetated by a low continuous sedgeland of *Machaerina juncea* but the margins support a dense shrubland of *Leptospermum lanigerum* grading into taller *Melaleuca ericifolia* and *M. squarrosa.* Underlying this vegetation is about 360 cm of peats which have formed over a very level sand sheet. This sand sheet has an elevation of approximately mean high water and contains organic material dated at 4070 ∓ 140 years B.P. (GAK 1680).

A core of peat and sand taken from the lake was annalysed for pollen content and the history of the lake over the last 4,000 years has been reconstructed by interpretation of local vegetation changes. The lake basin was probably formed much earlier than this when two east-west dunes built up on an older calcarenite surface. When the sea returned to the present level in this area about 6,500 years ago it may have formed a beach dune running north-south and blocking off the two east-west dunes. By 4000 years ago the sands were being laid down in water and a vegetation dominated by chenopods (possibly a salt marsh) was present at the site. With the cassation of sand sheet formation the vegetation produced a fibrous calcareous peat. *Myriophyllum, Triglochin* and sedges including *Machaerina* type were the major vegetation components and there was a very large amount of *Casuarina* pollen present suggesting that a *Casuarina stricta* woodland was present on the dune areas around the lake. This local vegetation and the type of peat suggests that the water was no more than 0.6–1.0 m deep at any stage and that it was periodically dry.

After 120 cm of this peat had formed a change occurred to a finely divided acid peat with no recognisable macro-plant remains. The plants typical of shallow freshwater decline while the pollen of a different sedge type and the colonial freshwater alga *Pediastrum* sp. become very important. These changes suggest that the lake deepened so that the depth permanently exceeded 1 m and it is possible that it filled to the present swamp surface giving a depth of 2.7 m. The time of this change is not known but may be less than 2,000 years ago.

Peat formation continued to infill the basin. Around the lake the *Casuarina* declined, reaching very low levels after European settlement in the region became apparent by the presence of Pine and weed pollen in the topmost 90 cm of peat. *Banksia*, grass and bracken *(Pteridium esculentum)* increase, possibly in response to burning and grazing, and these activities probably led to a sand blowout forming a sand sheet across the western half of the lake, over the peats. This sand sheet probably assisted the growth of the *Machaerina juncea* over the remainder of the lake surface where it now forms a quaking mat into which cattle and even a military vehicle have been lost.

The cause of the initial rise of water in Cotters lake and the later deepening many centuries later is not known; changes in the coastal barrier, in sea level or in climate may be invoked but require support from other sites before the question can be settled. The

slow infilling and final acceleration of plant succession by man has been recorded by the pollen more reliably however. If not disturbed by man the open swamp area will become drier and support thickets and even woodlands before marine erosion eventually carves the whole deposit away.

ROT POCKETS IN PRICKLY PEAR IN AUSTRALIA – AN EXAMPLE OF AN INTRODUCED REGENERATING HABITAT

(Abstract only)

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Three slides were shown. The first showed a stand of the common pest prickly pear, *Opuntia inermis,* near Ipswich, Queensland. This and other introduced pest cacti are controlled by a variety of organisms introduced specially for that purpose.

The second slide showed stems attacked by stem burrowing moth larvae *(Cactoblastus cactorum).* The thick fleshy stems had been opened to display the rot fluids which had accumulated. The dark brown liquid running from the rot pocket was clearly visable in a third slide. Even during periods of quite intense heat and aridity this liquid is prevented from drying up by the tough desiccation-resistant epidermis.

Rot pockets in cacti in the arid zones of the Nearctic Region are commonly exploited by aquatic insect species (Ryckman and Ames, 1953). Those in Australia are equally productive of a range of beetles and flies, some of which are certainly introduced (e.g. *Culicoides loughnani* Edwards)(Diptera, Ceratopogonidae).

These rot pockets in prickly pear are the only example known to the author of an introduced, regenerating, aquatic habitat.

Reference

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THE GIANT FRESHWATER CRAYFISH OF TASMANIA, *ASTACOPSIS GOULDI*

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The Tasmanian giant crayfish is a member of the family Parastacidae. Gould discovered the species in 1870 and the genus was erected by Huxley in 1878. The species was described by Clark in 1936. Currently there are three species of the genus with the possibility of other, as yet, undescribed ones.

Distribution of *Astacopsis gouldi* is restricted to the rivers and streams entering Bass Strait as well as to those streams of the West coast at least as far as Macquarie Harbour. It is absent from the Central Highlands and the rivers of the south east coast.

Astacopsis gouldi has the distinction of being the largest freshwater crayfish in the world. Individuals weighing 3 kg (= 7 lb) are common in some streams of the north west. It prefers to occupy deep still pools where cover is available under logs or overgrowing vegetation, but it also occurs in small swiftly running streams down as far as tidal waters.

Little is known about its breeding habits other than that newly hatched young are attached to females in the late spring. The aggressive habits of the giant freshwater crayfish have been partly responsible for the failure of captive freshwater crayfishes to survive in southern Tasmania. Several recent attempts to maintain populations at the Salmon Ponds

at Plenty have been unsuccessful. Specimens obtained from the Flowerdale River in 1960 died. In 1962 two adult berried females were transfered from Caroline Creek to Plenty. One of these produced 42 young in December of that year. Subsequently all died. The most recent attempt at maintaining a captive population was started in November 1967 when three crayfish, a male weighing 230 gm and females weighing 400 gm were brought from the Blythe River to the Salmon Ponds. One female died and the other female became soft shelled on the 6 February 1969. However, mating did not result and the female died on the 28 February 1969. The male was not observed to become soft shelled during its period of captivity.

A crayfish reserve was established in Caroline Creek in 1968 for the purpose of studying two habitats of the crayfish. The area reserved has two distinct components, one part of the creek is surrounded by exotic pine plantation and the other has eucalypts and tea tree. It is hoped that information gained from observations in the study area will provide a basis for the creation, if necessary, of larger reserves for the crayfish.

SOME ASPECTS OF FISH DISEASES

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This paper is a short review of fish diseases and parasites that may cause problems in connection with the intensive culture of fish. The survey is mainly, but not wholly, limited to the unnatural environment of a salmonid fish hatchery.

The main protozoan parasite which has caused heavy mortalities in Australian hatcheries is *Ichthyophthirius multifiliis.* This disease, "White Spot", is common in home aquaria and ponds, but epidemics under hatchery conditions are often disastrous. Severe infestations have been reported from Ballarat in 1939, 1940 (Butcher, 1941), 1956 (Wharton, 1956), 1968 and 1969; from Buxton, Victoria, in 1963; and from Tasmania at Plenty (Anon., 1933), Cora Lynn (Lynch, 1964) and Bridport (Purves, 1969). On a number of occasions the source of infestation has been determined, but in other cases there is some doubt. It is probably safe to say that the organism is well established in the fresh waters of southern Australia and Tasmania, with at least several of our native fish being susceptible or carriers, namely Blackfish *(Gadopsis marmoratus), Galaxias attenuatus,* and Short Finned Eel *(Anguilla australis)* (Butcher, 1947), and *Galaxias ornartus.*

Chilodoniasis is not as spectacular as the previous disease. The protozoan parasite, *Chilodonella cyprini,* is sometimes found on the gills and skin of wild fish, but in the hatching house at Snob's Creek, Victoria, it causes heavy losses in brown trout fry. The parasite causes severe gill irritation leading to swelling of the filaments, hyperplasia and subsequent death. The source of infection has not been definitely established, but the blackfish is suspected to be a carrier.

Chilodonella cyprini has been found on *Galaxias ornartus,* Australian Smelt *(Retropinna semoni),* Macquarie Perch *(Macquaria australisica)* and Blackfish. It caused heavy mortalities of Blackfish in a private dam in the 1968 drought.

Trichodiniasis is not well known in this country though the parasites were found on fish in Queensland rivers in the early 1920's (Johnston and Bancroft, 1922), but it is becoming apparent that this disease may be widely spread. At this stage I refer to the parasites as *Trichodina* sp. They have been found on Crucian Carp *(Carassius carassius),* Australian Smelt, Redfin *(Perca fluviatilis),* Rainbow trout *(Salmo gairdneri),* Brown trout *(Salmo trutta),* Golden Perch *(Plectroplites ambiguus),* Murray Cod *(Maccullochella macquariensis)* and Macquarie Perch. Under hatchery conditions, *Trichodina* sp. has caused mortalities in Rainbow trout fingerlings at Snob's Creek, at Albury, and possibly

Ballarat, and they have probably been responsible for mortalities in Macquarie Perch fry at Snob's Creek.

In Australia, bacterial diseases of fish have mainly been identified in crowded hatchery environments. This is not to say that fish under normal stream or lake conditions have not died from a bacterial epidemic. Bacterial infections such as Furunculosis or Columnaris in European or North American streams have not been recognised or indeed looked for. It is probable that some of the mortalities mentioned in the 1900's were due to bacterial infections (Johnston and Bancroft, 1922).

In fish hatcheries, the environment is favourable for bacterial multiplication. The foods fed to the salmonids are similar to constituents of bacterial media. The environment is probably very near to critical conditions due to faecal and excretory products and the lowering of oxygen tensions due to high densities of fish. These environmental changes all help to overload the resistance of the fish. I will discuss briefly two bacterial diseases recently detected at Snob's Creek.

Columaris disease appears to be a disease of adverse environmental conditions. The organism is one of the Myxobacterales (slime bacteria) possibly *Cytophaga columnaris* or *Chondrococcus columnaris.* Members of the order Myxobacterales are common soil and water bacteria. These organisms are possibly of no consequence to fish under favourable circumstances in the stream or in hatcheries, though they may be present on the skin of fish. But under environmental stress, such as high water temperatures, low oxygen tensions and/or weakening from other causes (including protozoan build up), these organisms can cause very high mortalities over a very short period. This happened at Snob's Creek Hatchery during the 1968 drought, when a pipeline burst and fish were stressed by lack of adequate water flow. This disease is highly contagious, but if identified early enough it can be controlled with copper dipping before it develops internally.

The other disease I will mention is called Nocardiosis. Very little work has been done by us on this disease, but it does not appear to be contagious, though its mode of transmission is at this juncture not clear. The causes seen have been caused by an acid-alcohol-fast bacillus of *Nocardia* sp.. One isolate has been identified as *Nocardia cavae* (Gordon, 1967). Some *Nocardia* species are found in the soil and are responsible for the very distinctive musty smell of the damp temperate zone rain forest. This smell also emanates forcibly from the organisms we have isolated.

In conclusion, it should be mentioned that two fish virus diseases have been tentatively recognised. Lymphocystic disease was found on an aquarium fish, a Paradise Fish *(Macropus opercularis)* (unpublished); and Sacramento River Chinook disease was found in a shipment of Quinnat Salmon in 1963 (Parisot *et al.,* 1965). Fortunately neither virus appears to be of any consequence to our existing fish stocks as they both appear to be species specific.

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ECOLOGY OF *CALAMOECIA TASMANICA* (COPEPODA : CALANOIDA)

(Abstract only)

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Some aspects of the ecology of the centropagid calanoid, *Calamoecia tasmanica* Smith, were discussed. The localities studied, in Victoria and King Island, are chemically similar to the Queensland localities investigated by Bayly (1964). These waters are characterised by low salinity, low calcium and bicarbonate concentration, low pH, and typically a high content of soluble allochthonous organic matter. They generally exist in sand-dune depressions underlain by an impermeable organic hardpan. The process of soil podzolisation, a consequence in this case of high coastal rainfall acting on quartzitic sands, accounts for this combination of characteristics.

The distribution of *C. tasmanica* was examined together with some experimental evidence to determine the importance of these factors to the occurrence of the copepod. On King Island there were a number of waters overlying podzolic, siliceous sands but abutting highly calcareous dunes. These localities had relatively high calcium concentrations (and presumably bicarbonate alkalinity) and *C. tasmanica* was absent. However, no mortality was observed in adults subjected to much higher levels of these ions in the laboratory. The fact that these "hard" waters had generally higher total salinities (720–2650 ppm cf. 200–650 ppm in "soft" waters) may be significant. While most occurrences were in acid waters (pH as low as 3.4), some were in markedly alkaline localities (e.g. pH 9.1), indicating that low pH *per se* is not necessary. The presence of humic acids appears to be most important. Other work indicates an association between high bacterial densities and humic acids. Considering the co-occurrence of high standing crops of *C. tasmanica* and low algal densities, bacteria are implicated as a food source. The ability of the copepod to ingest bacteria, at least as small aggregates, was demonstrated with erythrosin-stained bacilli and cocci cultured from humic water. In turn these probably utilise the imported, soluble sumic compounds.

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TEMPERATURE-INDUCED CHANGES IN OXYGEN AFFINITY OF THE BLOOD OF A NORTH AMERICAN FRESHWATER FISH

(Abstract only*)

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The affinity of blood for oxygen is dependent on temperature. This would seem to present a disadvantage to those fishes which encounter large seasonal temperature changes. Considering the well-known acclimatory abilities of many fishes, it would seem

reasonable to propose the occurrence of seasonal modification of blood oxygen equilibria to compensate for changes in temperature.

In *Ictalurus nebulosus* (Ictaluridae), blood from one group of fish acclimated at 24°C showed a consistently higher oxygen affinity compared with a group acclimated at 9°C, when measured at the same temperature. This shift, accompanying thermal metabolic acclimation, minimizes the effect of temperature on oxygen affinity. The shift did not persist when dilute solutions of haemoglobin were studied.

No changes with acclimation were seen in the multiple haemoglobin pattern nor in blood pH.

The erythrocyte, rather than the plasma, appears to be the site of modification.

Some large changes in erythrocyte potassium accompanied thermal acclimation, but the relation of this to the shift in oxygen affinity is unknown.

Australian inland fishes would seem to be good candidates for a similar study because of their tolerance of wide ranges of temperature.

* For full details see: *Comp. Biochem. Physiol.* 28:1203–23.

Editorial Note

THE FOLLOWING PAPER WAS NOT READ AT THE EIGHTH ANNUAL CONGRESS OF THE AUSTRALIAN SOCIETY FOR LIMNOLOGY. IT REPRESENTS AN ORIGINAL CONTRIBUTION SUBMITTED FOR PUBLICATION IN THE BULLETIN OF THE SOCIETY.

IS SOMERSET DAM POLYMICTIC OR MONOMICTIC?

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In a report of the natural history of Somerset Dam, Queensland, Stephenson (1953) noted that the water was in circulation almost continuously throughout the year, i.e. that the reservoir was polymictic (*sensu* Hutchinson, 1957). Whilst this may have been the case during 1948–52 when there were astasic water levels associated with construction and floods, it would be most unusual if it still is, since nearby reservoirs – Borumba Dam (Timms and Midgley, 1969), Enoggera and Gold Creek Reservoirs (personal communication, Brisbane City Council) and almost certainly Lake Manchester also (see later) – are warm momonictic lakes as defined by Hutchinson (1957).

In order to discover the present situation in Somerset Dam, temperature profiles were taken on 10th January, 1969 (between 1 and 2 p.m.) at three different stations, each about 0.8 km apart, in the main part of the reservoir. Admittedly, one such set of readings is insufficient to establish Somerset Dam's temperature regime, but if the reservoir stratifies at all, it is likely to do so in mid-summer, and this is the time when the readings were made. The average profile for the three stations is depicted in Fig. 1, together with the average profile (three stations) for Lake Manchester; all values were obtained in the morning of the same day. In each reservoir the values at each depth for each station were usually no more than 0.2°C apart, this being the accurancy of the resistance thermometer used. The exceptions were at shallow depths, the greatest variation being 1.4°C at 0.5 m in Somerset Dam.

From Fig. 1 it is obvious that Lake Manchester is thermally stratified with a well developed epilimnion and hypolimnion and with a narrow metalimnion with a steep gradient at the thermocline. Almost certainly it behaves like Borumba Dam and circulates in winter and so is of the warm monomictic type. Somerset Dam is also stratified with a well developed hypolimnion, but with an extensive metalimnion which merges into the

epilimnion. There is a 13.5°C difference between the surface and bottom temperature, more than twice that (6°C) recorded by Stephenson. Taking into account the likely range of diurnal variation in temperature, which would be about 4°C, and certainly no more than 6°C (Hussainy, 1967, and Timms, 1967), then this large surface-bottom temperature difference precludes the possibility of daily turnover. The presence of the well defined hypolimnion together with this temperature difference indicates that the reservior is stratified for at least the summer months.

From the above it is very likely that Somerset Dam is a warm monomictic lake. The difference in temperature profile between Somerset Dam and that for Lake Manchester and Borumba Dam (figure 3, Timms and Midgley, 1969) suggests that its thermal behaviour is different. The reason for this would be an interesting topic for further study; it is possibly related to the much greater surface area of Somerset Dam and the corresponding greater influence of the wind.

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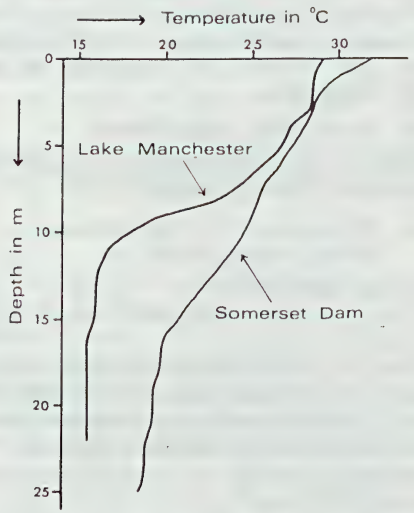

Fig. 1. Temperature profiles for Somerset Dam and Lake Manchester, 10 January, 1969.

PAPERS PUBLISHED ON AUSTRALIAN LIMNOLOGICAL TOPICS

(Compiled by A.L. Dyce)

At a committee meeting of the Australian Society for Limnology it was decided that the list of papers on Australian limnological topics (currently compiled by Mr. A.L. Dyce) is of such interest to overseas workers that it should be published in the *Bulletin,* and not, as was previously decided, circulated in the *Newsletter.*

The list below contains all references previously circulated in *Newsletter* 7(2) as well as those which have been compiled after the appearence of that *Newsletter.* Both sets of references have been integrated into a single list.

(A) 1965 (concluded)

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(no entry)

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NOTES TO AUTHORS

In addition to publishing abstracts or the full text of papers read at the Annual Congress of the Society, the *Bulletin* will publish original contributions of members that relate to Australian inland waters and/or their biota. These contributions may be strictly factual in content, or may be of a review nature. They will be subject to refereeing.

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